California Greenhouse Gas Emission Measurement Project (CALGEM)

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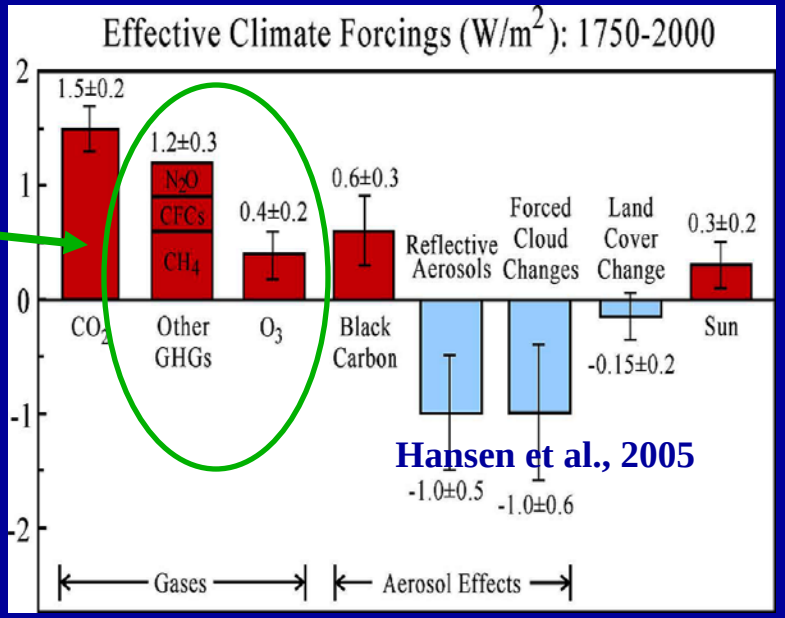
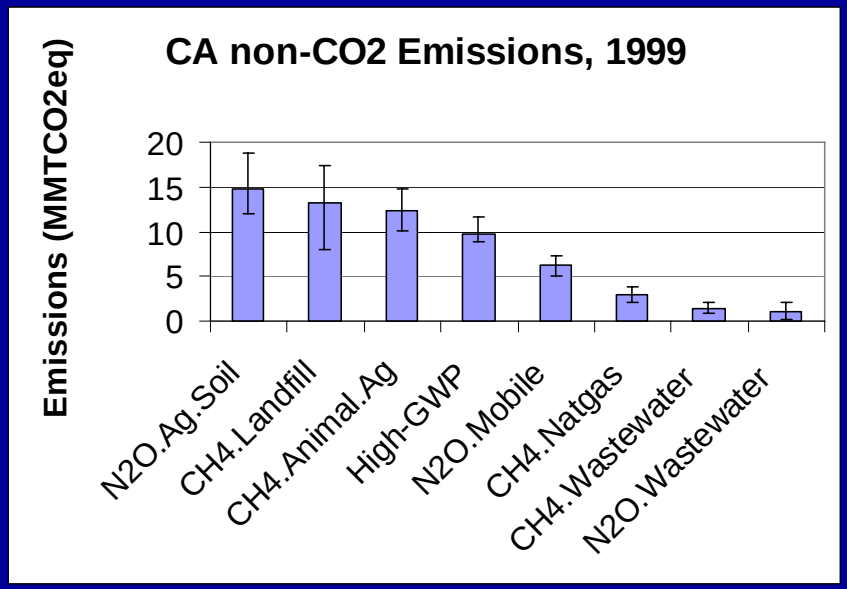
Outline

- CH_4 and non-CO_2 GHGs
  - Importance, uncertainty
  - Need for multiple emissions constraints
- Design of a regional measurement network
  - Emission inventory maps
  - Tower sites and instrumentation
  - Estimation of atmospheric signals
- Summary
- Further work

Overview of non-CO_2 GHGs

- Total non-CO_2 GHG forcing is ~ equivalent to CO_2 forcing globally
  - CH_4N_2O, High GWP
  - Tropospheric ozone
  - GHG feedbacks to climate change are likely (How big?)
- California non-CO_2 emissions:
  - equivalent to ~ 15% of CO_2
  - Large uncertainties because sources not readily metered
  - Currently, data are lacking to accurately scale up to state level
  - Alternately, look from top down using atmosphere for integration



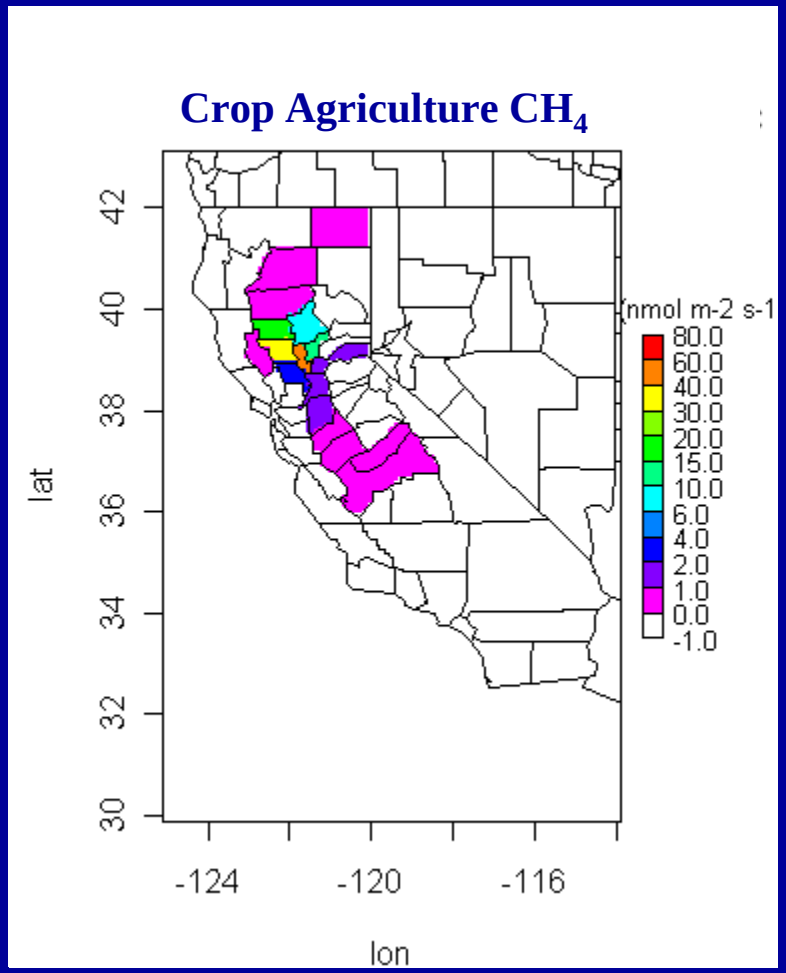


Constraining GHG Emissions with Atmospheric Data-Model Synthesis

- Essential ingredients:
  - A priori inventory estimates for spatiotemporal distribution of GHG and other tracers
  - Model for atmospheric transport and surface influence "footprints"
  - Continuous long term measurements of GHG and source attribution species (e.g., isotopes, atmos. tracers)
  - Quantitative GHG boundary conditions for regional problem
  - Bayesian statistical framework to evaluate improvement in emission estimates

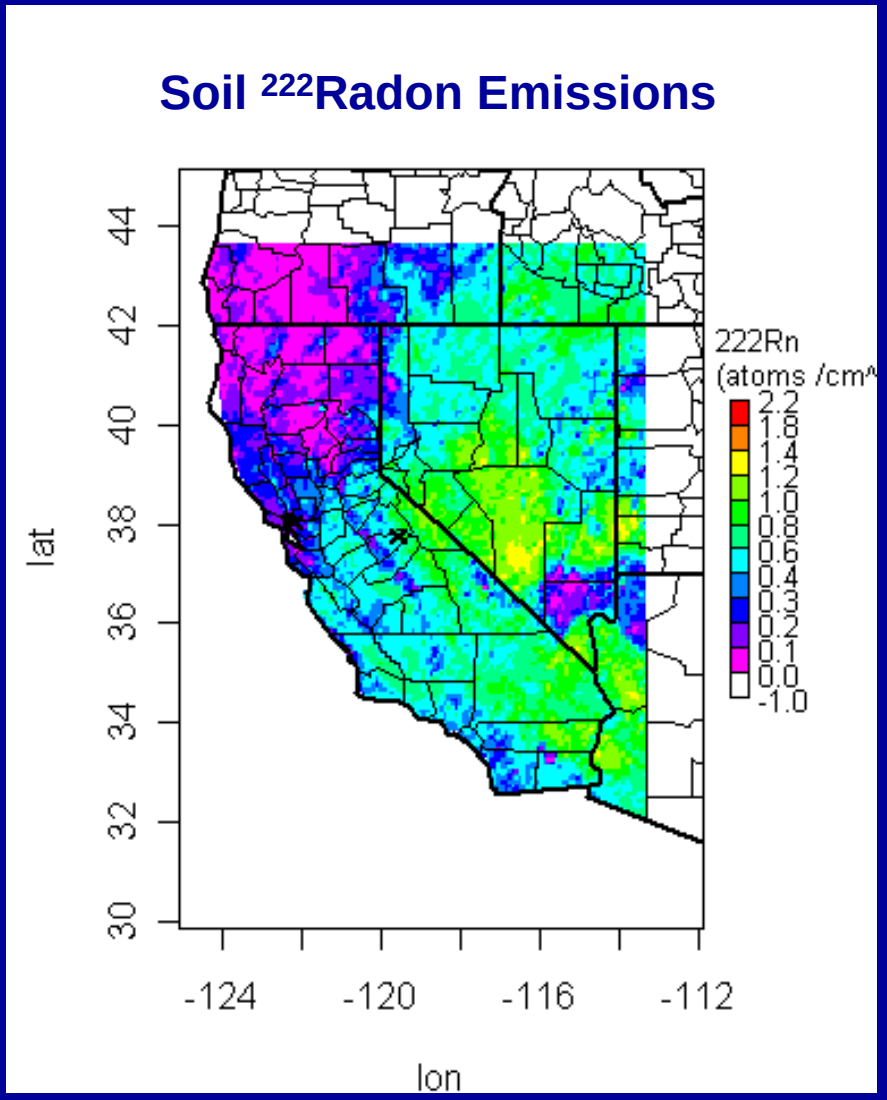
A priori CH_4 Emission Inventories

- Landfill
  - Landfill specific loading with substrate dependent residence time (EPA)
- Animal Ag.
  - USDA county level stocking
  - Dairy/meat emission factor
- Natural gas dist./use
  - County level facility/usage statistics (ARB)
- Wetlands
  - NASA-CASA (Potter, 2006)
- Crop Agriculture (July)
  - County level DNDC (Salas et al., 2006)



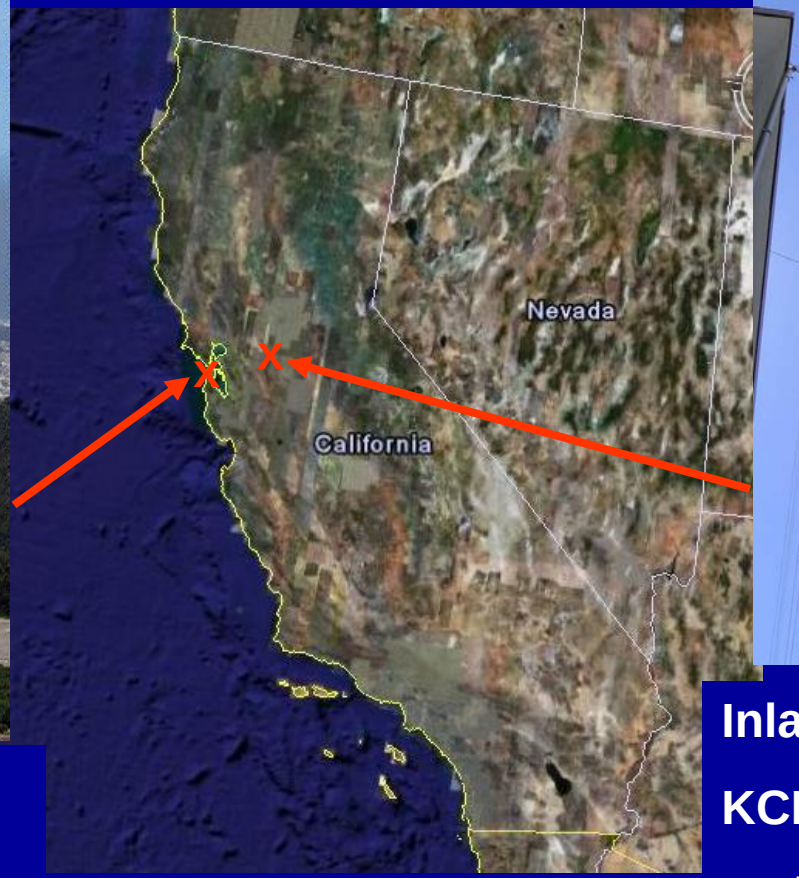
Atmospheric Mixing and Source Attribution

- ^{222}Radon can constrain atmospheric mixing (Hirsch, 2007)
  - Nearly ubiquitous soil emission
  - Atmospheric concentrations reflect recent emissions because of short half life (3.8 day)
  - Soil moisture is a factor
- Isotopic signatures
  - $^{13}CO2$ separate nat. gas vs. gasoline (Pataki, 2006)
  - ^{14}C not present in fossil fuel
  - $^{13}CH_4$, CDH_3 separate landfills and nat. gas
- CO, VOCs (specific to animals, crops, petroleum, etc.)



(Szegvary, 2006)

Initial Measurement Sites



Oceanic Site:
Sutro Tower,

San Francisco

(116, 230 m agl)

Inland Site:

KCRA Tower,

Walnut Grove

(30,100, 480 m agl)

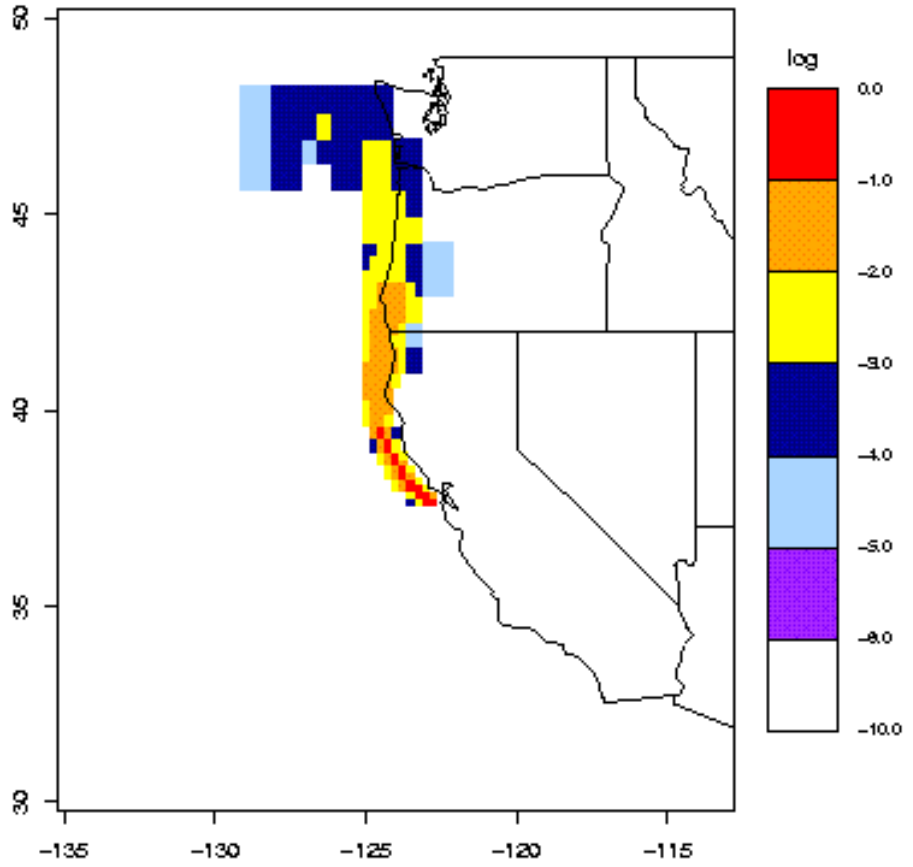
Measurement Instrumentation

- 12 Flask System
  - Twice daily samples
  - CO_2,CH_4,N_2O,CO
  - SF_6, halo carbons
  - $^{13}CO_2$, $^{13}CH_4$, CDH
- CH_4/CO_2 analyzer- 3min
- CO_2/CO rack – 3 min
- ^{222}Rn monitor – 30 min
- $^{14}CO_2$ (w/ LLNL soon)
- Collaborations sought

Predicting which Land Surface Affects the Measurements: The Footprint

- Stochastic time inverted Lagrangian particle trajectory (STILT) model predicts source regions contributing to measured signals
- Reguires mesoscale model (e.g., NOAA-EDAS, MM5/WRF) for winds, turbulence, convection

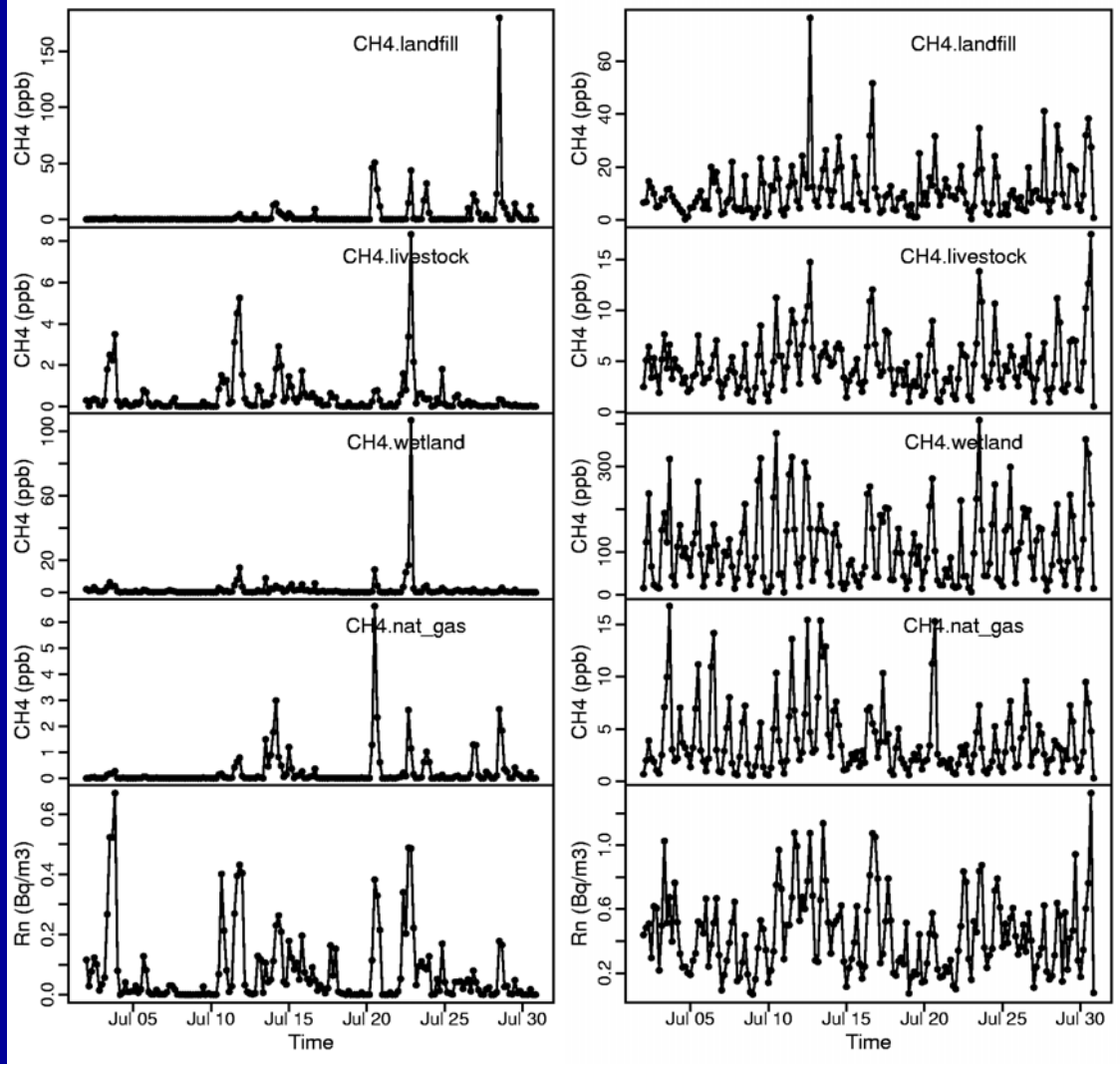
Area affecting concentrations at Sutro Tower (232 m), July 2005



Predicted CH_4 Signals

- Signals at Sutro dominated by background oceanic air
  - ^{222}Radon peaks show periods with influence of land surface
- Signals at KCRA dominated by emissions from central valley
  - Strong diurnal cycle from changing boundary layer height
  - Synoptic variations also apparent

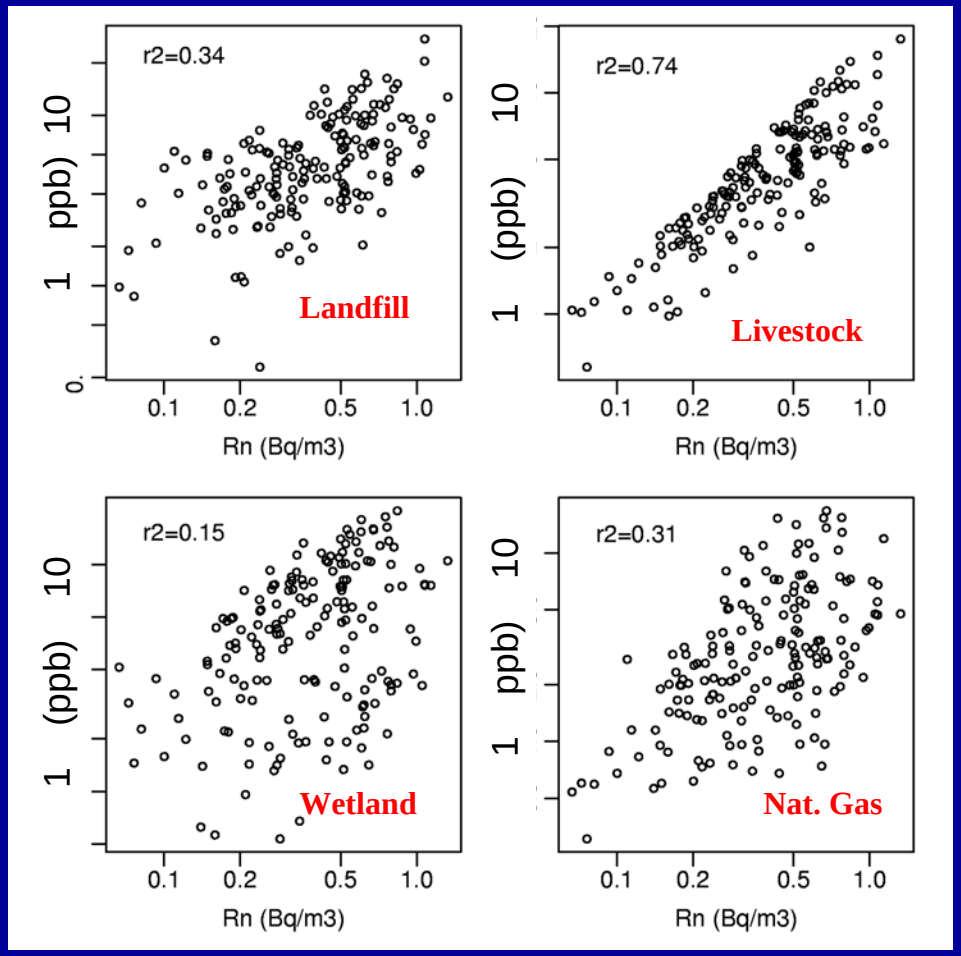
Sutro tower at 232 m KCRA at 100 m



CH_4 vs. ^{222}Rn Signals

- CH_4 signals correlated with ^{222}Rn
  - ^{222}Rn acts as a tracer of land surface influence
  - Measurements combined with quantitative footprints provides constraint on GHG emissions

KCRA at 100 m



Summary

- California's non-CO_2 GHG emissions significant and uncertain
- Long term atmospheric measurements will provide an independent and complementary method to constrain estimates of regional emissions
- Initial prediction of CH_4 signals suggest measurements can be achieved with planned instrumentation

Further Work

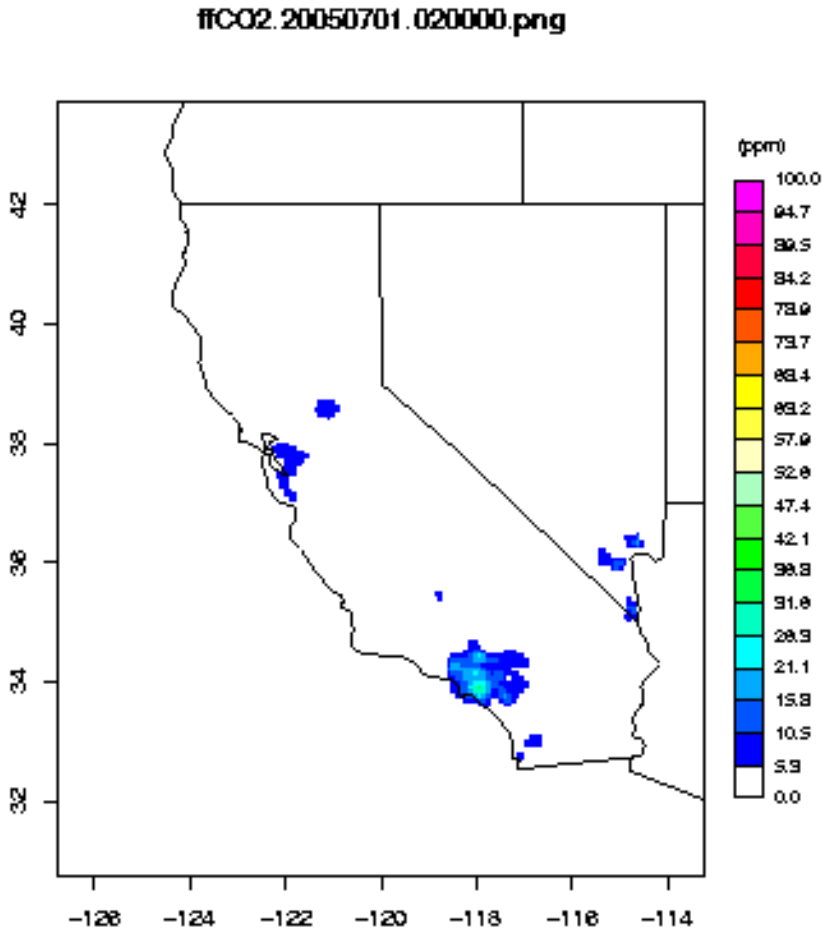
- Initiate measurements at Sutro and Walnut Grove Towers
- Develop and test high resolution meteorology for tower sites using MM5 and Weather Research Forecast (WRF) model
- Incorporate boundary conditions, isotopic tracers, and species for source attribution
- Initiate model-data-synthesis of regional GHG emissions and their uncertainties


Thank you

Example Transport Simulation: Atmospheric Signals of Fossil Fuel CO_2

- Forward model simulation
  - Fossil CO2 emissions scaled from EPA-NOx
  - MM5-Tracer
    - 10km resolution
    - Smaller nested grids possible over sub-regions of interest
  - Plumes from urban areas transport into surrounding regions

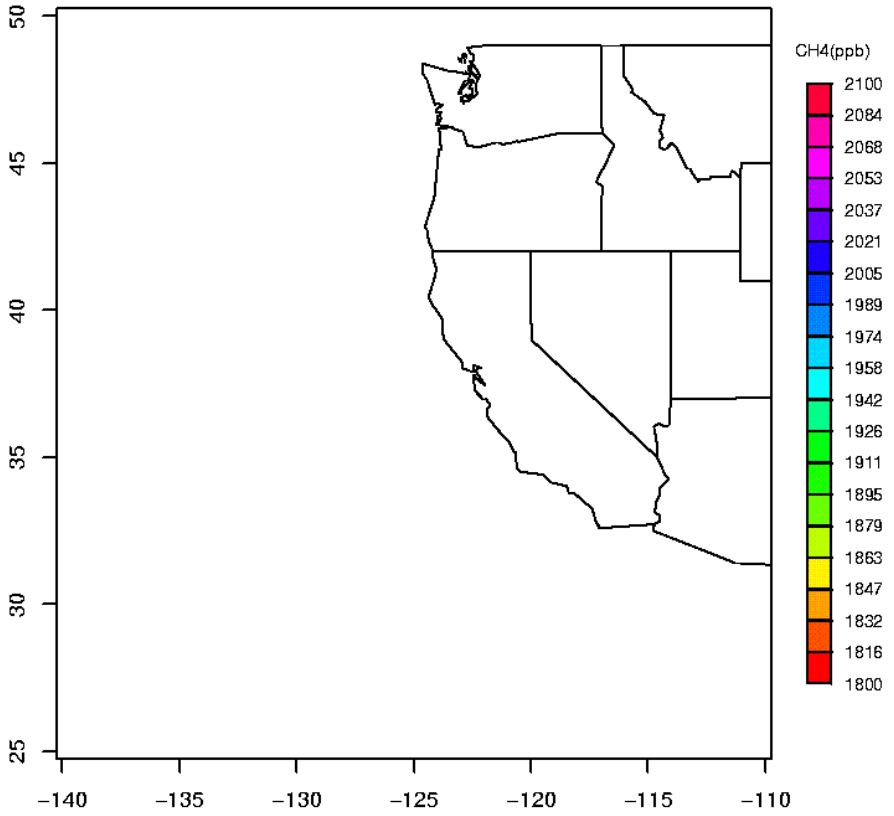
    (Riley et al., 2007)



Global Assimilated CH_4 Background

- Oceanic values indicate background air arriving at California
- Global assimilation results valuable for subtraction from tower “signals”
- Latitudinal gradients and long distance transport likely important
- Coastal measurements also needed to capture unresolved variations in background CH_4

Monthly mean CH_4 for 2003



Bousquet et al., (2004)